Detonation Flame Arrestor Element Replacement & Soil Vapor Extraction Pilot Test

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EXECUTIVE SUMMARY

Clayton Group Services, Inc. (Clayton) has completed the installation of new detonation flame arrestor elements on the vapor control system (VCS) and has also conducted a soil vapor extraction (SVE) pilot test on a vapor recovery well (HSVE-1) recently installed adjacent to existing vapor control boring VCB-1. The pilot test evaluated the use of SVE as a remediation approach. Historical data has shown that the system effectiveness may decrease by an order of magnitude during times of high water table conditions.

Previous visual inspections of several vapor control borings (VCB) identified accumulations of a "hydrocarbon paste" throughout the interior (piping, filters) of the VCS. The same hydrocarbon paste material was discovered to have accumulated within the baffles of the detonation flame arrestor elements, greatly reducing airflow from the VCBs. For this reason, the detonation flame arrestor elements required replacement.

The primary objectives of these activities were to first determine the effect of replacing the detonation flame arrestor elements on the VCS system airflow and vacuum and, secondly, to evaluate the effective ROI from a new vapor extraction well.

After installing the new arrestors, it became evident the hydrocarbon paste within the VCBs was resulting in excessive pressures and loads on the VCS. As a result, a SVE pilot test was conducted on a single new extraction well to determine the maximum potential effective ROI from a new well. By comparing these data with that of the existing VCBs, it would be possible to determine if the VCBs are impaired.

The detonation arrestor replacement activities were conducted from December 15-18, 2003. Pertinent findings of these activities are summarized below:

- The baffles of the detonation arrestors were impaired, resulting in a pressure drop at the blower and a reduced vacuum/flow at the VCBs. The new arrestors have eliminated the pressure drop, and now allow for greater vacuum and flow from the VCBs.

- Even with clean detonation arrestors with no pressure drop, the radius of influence from the VCBs is low. The extent to which the ROI may be reduced would be determined by a comparison SVE test (conducted on a newly installed vapor extraction well).

- The high vacuums at the existing VCBs that are set into the water table will theoretically result in a lifting of the water/hydrocarbon level (~12 feet) within the VCBs. Depending on seasonal water levels, this heightened liquid level will essentially block the extraction screen and/or the native sand unit, or reduce the allowable extraction screen to less than approximately 8 feet, thus reducing the ROI of the VCBs.

The SVE test was conducted on January 14, 2004 for a period of 14 continuous hours.

The pertinent findings of the pilot test are summarized below:

- The well screens of the existing VCBs limit the effective ROI within the subsurface. The existing VCB-1 has an effective ROI of approximately 20 feet. The new extraction well (HSVE-1) has an effective ROI beyond the furthest vacuum monitoring point of 100 feet. Extrapolation of the ROI data beyond this point shows an estimated effective ROI between 150 to 200 feet for the new extraction well.

- Groundwater or free product was not detected in the new extraction well after testing, and neither groundwater nor water vapors were entrained by the SVE system during the test. New SVE wells set above the water table are not expected to experience reduced effectiveness due to lifting of the water/hydrocarbon level above the well screen or native sand units.

- The new extraction well exhibited lower vacuums than the existing VCBs with similar flows. The elevated vacuums at the VCBs require ambient air dilution to prevent VCS shutdown. The addition of ambient air further reduces the effective ROI of the VCBs.

- The shallow (0 to 20 feet below surface grade [bsg]) fine-grained alluvial materials do not appear conducive to SVE technology. The cohesive nature of these materials limits airflow above 20 feet bsg and does not produce a measurable ROI within these materials beyond 18 feet. The preferred pathway for airflow within the subsurface appears to be within the dry sandy materials that exist above the water table. These sandy materials yielded effective extrapolated ROIs of approximately 150 to 200 feet.

- Historical data from an air sample collected from the Thermal Treatment Unit (TTU) in July 2003 identifies that the removal rate for the entire TTU (all 12 VCBs) was approximately 60 lbs/day or 2.5 lbs/hr. Extrapolating the pilot test results from one well to 12 new wells results in a potential hydrocarbon extraction rate of 6,312 lbs/day or 263 lbs/hr.

1.0 INTRODUCTION/OBJECTIVE

1.1 INTRODUCTION

This document details the Vapor Control System (VCS) detonation flame arrestor element replacement activities conducted between December 15 and 18, 2003, as well as the findings of the Soil Vapor Extraction (SVE) pilot test conducted within the Village of Hartford, Illinois on January 14, 2004. The pilot test evaluated the use of SVE as a remediation approach. Historical data has shown that the system effectiveness may decrease by an order of magnitude during times of high water table conditions.

Previous evaluations of the VCS have identified that the system requires ambient air dilution to keep operating parameters (vacuum, hydrocarbon concentration, and motor load levels) within appropriate specifications of the system. Previous visual inspections of the interior of several vapor control borings (VCBs) identified accumulations of "hydrocarbon paste" within the well screen. The same hydrocarbon paste material was discovered to have accumulated within the baffles of the detonation flame arrestor elements, greatly reducing airflow from the VCBs. For this reason, the detonation flame arrestor elements required replacement.

1.2 OBJECTIVES

The primary objectives of these activities were to first determine the effect of replacing the detonation flame arrestor elements on the VCS system airflow and vacuum and, secondly, to evaluate the effective ROI from a new vapor extraction well.

Following installation of the new detonation flame arrestor elements, the operating parameters of the VCS would be measured and compared with the baseline readings obtained during previous evaluation phases. In the event the detonation flame arrestor element replacement did not increase the ROI of the VCBs, a SVE pilot test would be conducted in a new extraction well. By comparing the effective ROI results of the existing VCBs with that of the newly installed vapor recovery well, it would be possible to determine the extent, if any, to which the effective ROI of the VCBs is reduced.

Specific details regarding the above-referenced activities are detailed in the sections below.

2.0 DETONATION FLAME ARRESTOR ELEMENT REPLACEMENT ACTIVITIES

Results from previous evaluations of the VCS performance (conducted in July and October 2003) identified little airflow and vacuum influence within the subsurface at the existing VCBs. During the October evaluation, it was determined that the detonation flame arrestors were coated with an orange-to-brown pasty material having a consistency similar to dry peanut butter ("hydrocarbon paste"). This foreign material filled the baffles of the detonation arrestors to a point where the arrestors were creating a pressure drop on the vacuum side of the blowers. The pressure drop required the ambient air dilution valve (ADV) to be opened to limit loads and pressures on the VCS and prevent system shutdown.

The objective of these field activities was to install new detonation arrestors, thereby potentially increasing both vacuum and flow at the VCBs. Resulting ROI and system performance data (overall vacuum) were to provide a clear picture on the condition of the existing VCBs.

2.1 FIELD ACTIVITIES

Clayton conducted the onsite field activities from December 15, 2003 to December 18, 2003. The old arrestor elements were removed on December 15, 2003. On this same day, both pre-filter elements ("witch's hats") were cleaned to remove any accumulated materials. The witch's hats were last cleaned in October 2003 during the initial inspection of the detonation arrestors. Since October, the witch's hat had accumulated hydrocarbon residue.

The new detonation flame arrestor elements were installed on December 16-17, 2003. New gaskets were used to ensure an airtight seal between the new arrestor elements and the process piping. On December 17, 2003, the VCS was re-started and evaluated for performance.

2.2 PERFORMANCE EVALUATION

The VCS was restarted with all valves in the same position as they were prior to the new arrestor element installation (the ADV halfway open and the well inlet valve fully open). Upon restarting the VCS, it was evident the pressure drop that existed across the arrestor elements had been eliminated. The new arrestors were performing within the specifications of the manufacturer, and the ADV was slowly closed to allow for an incremental increase in vacuum and flow at the VCBs.

With the ADV fully closed, the system was monitored for performance. The vacuum at the VCBs was equal to the vacuum at the blowers, suggesting little-to-no pressure drop through the process piping. The system was performing within the allowable specifications, although the vacuum throughout the system was near the system design limit of 15 inches of Hg. This high vacuum was now being generated at the VCBs. This information supports the original conclusion drawn from the visual inspection of the interior of the VCBs, where the well screens were discovered to be covered with the hydrocarbon residue. The degree to which the VCBs were impaired could not be determined until an SVE pilot test was conducted to compare flow, vacuum, and ROI data from a new extraction well.

It should also be noted the increased vacuums at the VCBs would have theoretically resulted in a lifting of the water/hydrocarbon level (~12 feet) within the VCBs. Depending on seasonal water levels, this heightened liquid level would have essentially blocked the extraction screen and/or the native sand unit, or reduced the allowable extraction screen to less than 8 feet, subsequently reducing the ROI of the VCBs.

After approximately one hour of operating with the ADV closed, the system automatically shut down. This shutdown could have resulted from a surge condition on the blower (increased blower load), a high temperature exhaust condition, or a high water level in the subsurface process piping. Following several additional tests after restarting the VCS, it was concluded the high temperature exhaust condition was not likely the cause of the shutdown, and that a blower surge condition was the most probable reason for the shutdown (due to the relative quickness the blower shut down on subsequent starts). It is likely the blower surge condition is occurring due to the high vacuums produced by the existing VCBs. Because the system does not have a complete telemetry system, the exact cause of the shutdown could not be determined.

For this reason, the ADV was opened approximately 25% to reduce vacuum loads and avoid blower surge conditions. Once the ADV was opened, the VCS operated for extended periods. During this time, ROI readings and individual vacuum/flow readings were collected from the VCBs. These data identified an increased flow and vacuum from each VCB, as expected. The increased flows/vacuums produced greater ROI readings in one of the three VCBs tested (VCB-12). The other two VCBs tested for ROI (VCB-1 and VCB-6) had approximately the same low ROI as before removal of the detonation arrestor. The likely explanation for this is the high vacuum and subsequent heightened liquid level that would have essentially blocked the native sand unit in VCB-1 and VCB-6, but not in VCB-12, due to a thicker sand unit. Table 1 provides the vacuum measured at the monitoring probes associated with VCB-1, VCB-6 and VCB-12 before and after the flame arrestor was replaced.

Several days after installation of the new flame arrestors, the increased flows from the VCBs (and correspondingly the increased recovery of hydrocarbons) resulted in a VCS shutdown due to high exhaust temperatures within the Thermal Treatment Unit (TTU). In order to manage the operation of the TTU, the inlet valve to the VCBs was closed 25% to allow less air from the VCBs and more ambient air into the system.

2.3 CONCLUSIONS

The detonation arrestor replacement and subsequent evaluation activities completed between December 15 and December 18, 2003 have provided sufficient information regarding the potential for optimization of the VCS.

The following conclusions were made based on the above-referenced testing:

- There was a pressure drop across the baffles of the detonation flame arrestor elements resulting in a reduced vacuum/flow at the VCBs. The new arrestor elements eliminate the pressure drop and allow for greater vacuum and flow from the VCBs.
- Even with clean detonation arrestors with no pressure drop, the ROI from the VCBs is low. The extent to which the ROI may be reduced would be determined by a comparison SVE test (conducted on a newly installed vapor extraction well).
- The high vacuums at the existing VCBs that are set into the water table will theoretically result in a lifting of the water/hydrocarbon level (~12 feet) within the VCBs. Depending on seasonal water levels, this heightened liquid level will essentially block the extraction screen and/or the native sand unit, or reduce the allowable extraction screen to less than approximately 8 feet, thus reducing the ROI of the VCBs.

3.0 SOIL VAPOR EXTRACTION PILOT TEST

A 14-hour SVE pilot test was performed on a new extraction well (HSVE-1) recently installed adjacent to existing vapor extraction well VCB-1. The SVE pilot test was conducted to provide the necessary data required to determine the expected ROI from a single extraction well. In addition, by comparing the effective ROI results of the existing VCBs with that of the newly installed vapor recovery well, it would be possible to determine if the exiting VCBs are impaired.

The SVE testing was conducted in accordance with the Army Corps of Engineers guidance EM 1110-1-4001 Soil Vapor Extraction and Bioventing, dated June 2002. The extraction well installation procedures, testing parameters, data collection methods, and results are provided in the following sections.

3.1 PILOT TEST WELL AND EQUIPMENT INSTALLATION

One vapor extraction well (HSVE-1) was installed in the immediate vicinity of existing vapor extraction well VCB-1. The new extraction well was constructed to extract air/vapors from the cohesive materials that comprise the upper approximate 20 feet of soil. Existing monitoring probes (previously installed to measure ROI from VCB-1) were utilized to measure subsurface airflow conditions and vacuum responses generated at radial distances of 18, 25, 50, 75, and 100 feet from the new extraction well. The locations of the new extraction well and monitoring probes are provided in Figure 1.

Extraction well HSVE-1 was constructed of 4-inch inside diameter (ID), stainless steel well screen with steel riser pipe. The screen consists of 10 feet of 0.020-inch slotted openings situated to intersect the vadose zone soils from 7 to 17 feet below surface grade (bsg). The well log and the well completion report for HSVE-1 are provided in Appendix A-1. The well depth and screening interval was determined based on the completion log information from VCB-1 and the completion log information for the vapor monitoring probes installed near VCB-1 for use during earlier VCS evaluation activities. It was the intent of the well construction to have the screen placement be at or near the interface between the overlying fine grain materials and the sand unit at this location. This would reduce the potential for water entrainment, while allowing connection to the sand zone for vacuum extraction.

The monitoring probes consist of 1-inch ID, Schedule 40, polyvinyl chloride (PVC) pipe with 0.010-inch screen. The monitoring probes exist in "nests" at select radial distances from the extraction well. Each nest consisted of two distinct subsurface monitoring points (screened intervals) within the subsurface soils. The purpose of the probe nests was to measure vacuum (subsurface airflow) at two distinct units across the subsurface. The screened intervals of the probes were situated to correspond with the deeper (sand) unit and shallower (fine-grained cohesive clays/silts) unsaturated portions of the subsurface.

The shallow probes (6S, 7S, 8S, and 9S) were constructed with screened intervals between 5 to 10 feet bsg. Screened intervals for the deep probes (6D, 7D, 8D, and 9D) were between 17 to 27 feet bsg.

Copies of the construction logs for VCB-1 and vapor monitoring probes MP-6S and MP-6D (closest probes to HSVE-1) are provided in Appendix A-2.

The test was conducted using a mobile skid-mounted SVE module that included a 7.5 horsepower (hp) explosion-proof motor with a three-phase sealed regenerative blower capable of achieving 200 cubic feet per minute (cfm) at 40 inches of water column (W.C.). The performance specifications and curve for the blower are provided in Appendix B. The SVE module included a 50-gallon water trap/knock out with demister/filter, an exhaust silencer, and a manual ADV. The ADV controlled flow rates/vacuums at the extraction well and provided for manual control of the process vapor concentrations by introducing ambient air into the air stream. Additional process control features such as float switches, flow gauges, and vacuum relief valves were also integrated within the SVE module to optimize blower performance.

The SVE module was situated adjacent to extraction well HSVE-1. The top of the extraction well was connected to the inlet of the SVE module using 4-inch ID, Schedule 40 PVC pipe, and threaded couplings. A pitot tube was inserted along a straight section of the SVE inlet pipe to measure airflow from the extraction well during the pilot test. An air sampling port and air stream temperature gauge were also inserted into the extraction well inlet piping to monitor volatile organic compound (VOC) concentrations and air temperatures of the influent air stream. The SVE exhaust was routed through a 5,000-pound granular activated carbon (GAC) vessel using 4-inch ID, Schedule 40 PVC pipe, and flanged fittings. The carbon vessel was utilized to remove VOCs from the exhaust air stream prior to discharge to the atmosphere. A pitot tube, temperature gauge, and sampling port were also inserted along a straight section of the exhaust discharge pipe to measure flow rate, temperature, and VOC concentration of the effluent air stream, respectively. Figure 2 shows a generalized schematic of the SVE pilot test set up.

3.2 PILOT TEST OPERATION

The SVE pilot test was conducted as a step test for a period of 14 hours. Prior to the test initiation, the SVE module was operated with the ADV completely open to evaluate the operation of the equipment and perform any necessary maintenance prior to initiating the test. During this time, all flow, pressure, and temperature gauges were calibrated. In addition, prior to initiation of the pilot test, the valve to VCB-1 was closed so the existing VCS did not influence the pilot test.

In order to establish baseline subsurface pressure data, pressure readings were collected from all of the subsurface vacuum monitoring probes prior to start of the test. None of the vacuum monitoring probes exhibited pressure readings above/below 0.0 inches of W.C.

The pilot test was conducted as a step test with extraction well flow rates of 50 cfm, 75 cfm (low vacuum), 100 cfm, and 75 cfm (high vacuum). The first three-step tests were conducted with the ADV partially open to allow for control of flow and vacuum at the extraction well. The ADV was incrementally closed at each of the step tests to allow for greater flow and vacuum at the extraction well. The high vacuum 75 cfm test was conducted with the ADV fully closed. Each step consisted of inducing different vacuum levels at the extraction well in order to measure the SVE module operating parameters, VOC removal effectiveness, and various airflow parameters under select flow conditions. The operating parameters of the SVE module and field test parameters measured during the baseline and step tests are discussed in Section 3.3.

Each step (flow rate) was conducted for a period of between 1 to 5 hours to maximize data collection at each rate. During this period, ROI (vacuum response) measurements were recorded at each multi-port monitoring probe until readings stabilized. In addition, air samples were collected from the influent air stream (well head prior to air dilution) and the exhaust air stream (post carbon adsorption vessel) using 1-liter tedlar bags. Tedlar bag samples were screened with a photoionization detector (PID) to monitor total VOC concentration within each air stream. At this same time, influent airflow rates, exhaust airflow rates, and well head vacuum readings were recorded. Near the middle of each step and at the end of each step, an air sample was collected from the influent air stream (well head prior to air dilution) using laboratory pre-evacuated 6-liter summa canisters. In addition, a single air sample (summa canister) was collected from the exhaust (post carbon) of the SVE module at the completion of the test to document the removal capacity of the carbon at the end of the test. The summa canisters were submitted to Columbia Analytical, Inc. (Columbia Analytical) in Simi Valley, California for United States Environmental Protection Agency (USEPA) Method TO-3 (total petroleum hydrocarbons [TPH] as gasoline).

The test was completed on January 14, 2004. All equipment and process piping used during the test was disassembled and decontaminated prior to leaving the Site.

3.3 DATA COLLECTION

The operating parameters of the SVE module and select field test parameters were measured at regular intervals during the pilot test. During each step test, SVE parameters were recorded regularly.

The operating parameters of the SVE module and the field test parameters measured during the pilot test are listed below:

- Airflow rate and vacuum at the extraction well.
- Relative organic vapor concentration of the influent air stream (prior to air dilution).
- Airflow rate of the exhaust air stream (post carbon adsorber).
- Relative organic vapor concentration of the exhaust (post carbon adsorber).
- Vacuum response at each monitoring probe.

The airflow rate at the SVE well was measured to determine the subsurface airflow conditions at the extraction well. This velocity was measured using a pitot tube connected to a Magnehelic gauge to measure differential pressure. The airflow velocity was then converted to a standard airflow rate based on the cross-sectional area of the process pipe and a standard air density of 0.075 lbs/ft^3.

The vacuum, total (exhaust) airflow rate, and exhaust temperature at the SVE unit were measured to determine the performance of the blower relative to the subsurface soils and extraction well design, the airflow loss between the extraction well and inlet of the SVE unit, and the overall operating system performance. The airflow velocity of the exhaust air stream was measured using a pitot tube connected to a Magnehelic gauge to measure differential pressure (as previously described with the influent airflow rate). The vacuum was measured directly using a vacuum gauge tapped into the water trap (post ADV) of the SVE unit.

The vacuum response was measured at each vapor monitoring probe to determine the vacuum distribution or ROI of the extraction well. The vacuum levels were measured using Magnehelic negative pressure gauges attached to the top of each monitoring probe with a quick-connect air lock fitting. The accuracy of the vacuum gauges is approximately ± 0.02 inches of W.C.

Air samples were collected from the influent air stream (prior to air dilution) and the exhaust air stream (post carbon adsorber) to monitor the influent VOC concentrations and measure the efficiency of the activated carbon to adsorb VOCs from the air stream. The air samples were collected using tedlar bags and pre-evacuated 6-liter summa canisters as described in Section 3.2. The summa canisters were submitted to Columbia Analytical for total organic analysis using USEPA Method TO-3 (total petroleum hydrocarbons as gasoline). Laboratory analytical reports for the summa canister air samples are included in Appendix C.

3.4 SVE PILOT TEST RESULTS

Performance data collected from the SVE module, field test measurements, and analytical results of the air samples were evaluated after the completion of the pilot test. The data generated during the pilot test provided a basis of comparison between an existing VCBs and a newly installed VCB. The removal rate of the VOCs measured during the pilot test provided potential removal efficiency of the compounds from the subsurface and emission rates from a single extraction well.

3.4.1 Air Flow Rate and Vacuum

Airflow rates and vacuums measured at the extraction well ranged from 50 cfm, 75 cfm, and 100 cfm, with 10, 27, and 43 inches W.C., respectively. An additional step test was conducted with a wellhead flow rate of 75 cfm and a higher vacuum of 94 inches of W.C. Airflow rates and vacuum levels measured during each step test are summarized in Table 2.

Neither groundwater nor water vapors were entrained by the SVE system during the pilot test. Groundwater or free product was not detected in the pilot test well before or after testing.

3.4.2 Vacuum Response and Radius of Influence (ROI)

The vacuum response at each multi-port monitoring probe was recorded to determine the vacuum distribution in the subsurface soils and ROI under various test conditions. The effective ROI is defined in the literature as the distance at which air is advectively drawn towards the extraction well at a rate that will effectively remove contaminants from the soil. The steady-state vacuum response measurements at the multi-port monitoring probes under the various test conditions are listed in Table 3.

Vacuum readings ($\geq$ 0.1 in. W.C.) were detected at all deep monitoring probes locations (screened in the sand) at extraction well flow rates of 50 scfm and greater (well head vacuums of 9.5 inches W.C. and greater). Extraction well flow rates from 25 to 50 cfm (5 to 10 inches W.C.) generated vacuum readings greater than 0.1 inches W.C. at the 20 and 50 foot monitoring probe locations (screened in the sand unit). A graphic illustration of ROI readings at select extraction well flow rates and vacuums are provided in Figures 3 and 4.

The shallow monitoring probes screened in the fine-grained cohesive materials (silty clays/clayey silts immediately above the sand unit) registered 0.0 inches of W.C. throughout the tests, with the exception of the monitoring probe closest (~18 feet) to the extraction well. This information suggests the cohesive nature of these materials limits airflow and does not allow an effective ROI within these materials beyond 18 to 20 feet. These data suggest the preferred pathway for airflow within the subsurface appears to be within the sandy materials that exist immediately above the water table. In addition, these data provide evidence that the overlying fine-grained materials are an effective natural barrier to short-circuit air through the surface.

3.4.3 Air Sample Analytical Results

To quantify the removal of specific VOCs from the soils during the pilot test, and to ensure carbon adsorber removal efficiencies, air samples were collected from the influent air stream (prior to air dilution) and exhaust airstream (post carbon adsorber) using summa canisters as discussed in Section 3.3. The analytical results of the air samples are summarized in Table 2. A copy of the laboratory analytical report is included in Appendix C.

3.4.4 Hydrocarbon Extraction Rates

The removal rate of TPH (in lbs TPH/day) during the SVE-1S pilot test was calculated from the TPH concentration (mg/m^3) detected in each inlet air stream sample (Summa canister sample).

The TPH removal rate (in lbs/day) was determined using the following calculation:

$R_r = C_v \times Q_s$ (where C_v is the known concentration TPH and Q_s is the measured influent air stream flow rate)

To calculate the removal rate (R_r) in lbs/day, the concentration was converted to lbs/L and the flow rate converted to L/day. The conversions were as follows:

C_v(lbs/L) = C_v(mg/L) x kg/1,000,000mg x 2.205 lbs/kg

and

Q_s(L/day) = Q_s(ft^3/min) x 60 min/hr x 24 hr/day x 28.317 L/ft^3

Using the above-referenced calculations and the influent air stream Summa canister laboratory analytical results, the TPH removal rate in lbs/day is as follows:

R_r (at 50 cfm) = ~26 lbs TPH/day or 1.1 lbs/hr

R_r (at 75 cfm) = ~378 lbs TPH/day or 16 lbs/hr

R_r (at 100 cfm) = ~503 lbs TPH/day or 21 lbs/hr

R_r (at 75 cfm –high vacuum greatest ROI) = ~526 lbs TPH/day or 22 lbs/hr

Hand calculations of the TPH removal rates in lbs/day are presented in Appendix D.

Historical data from an air sample collected from the TTU in July 2003 identifies that the removal rate for the entire TTU (all 12 VCBs) was approximately 60 lbs/day or 2.5 lbs/hr. To determine the potential hydrocarbon removal rate for 12 new VCBs, the single well data could be extrapolated to include 12 new wells by simply multiplying the results from the high vacuum 75 cfm test (526 lbs/day) by 12 to get a total of 6,312 lbs/day or 263 lbs/hr). This represents a TPH (as gasoline) recovery rate increase greater than 100 times of that with the existing wells.

4.0 SUMMARY OF RESULTS

Evaluation of the SVE pilot test data generated the following conclusions:

- The well screens of the existing VCBs are limiting the effective ROI within the subsurface. The existing VCB-1 has an effective ROI of approximately 20 feet. The new extraction well had an effective ROI beyond the furthest vacuum monitoring point of 100 feet. Extrapolation of the ROI data beyond this point shows an estimated effective ROI between 150 to 200 feet for the new extraction well.

- The new extraction well exhibited lower vacuums than the existing VCBs with similar flows. The elevated vacuums at the VCBs require ambient air dilution to prevent VCS shutdown. The addition of ambient air further reduces the effective ROI of the VCBs.

- Groundwater or free product was not detected in the new extraction well after testing, and neither groundwater nor water vapors were entrained by the SVE system during the test. New SVE wells set above the water table are not expected to experience reduced effectiveness due to lifting of the water/hydrocarbon level above the well screen or native sand units.

- The shallow fine-grained materials between 0 to 20 feet bsg do not appear conducive to SVE technology. The cohesive nature of these materials limits airflow above 20 feet bsg and does not allow an effective ROI within these materials beyond 18 feet. The preferred pathway for airflow within the subsurface appears to be within the dry sandy materials that exist immediately above the water table. These sandy materials yielded effective extrapolated ROIs of approximately 150 to 200 feet.

- Historical data from an air sample collected from the TTU in July 2003 identifies that the removal rate for the entire TTU (all 12 VCBs) was approximately 60 lbs/day or 2.5 lbs/hr. To determine the potential hydrocarbon removal rate for 12 new VCBs, the single well data could be extrapolated to include 12 new wells by simply multiplying the results from the high vacuum 75 cfm test (526 lbs/day) by 12 to get a total of 6,312 lbs/day or 263 lbs/hr. This represents a TPH (as gasoline) recovery rate increase greater than 100 times of that with the existing wells.

5.0 EVALUATION OF OPTIONS/RECOMMENDATIONS

5.1 EVALUATION OF OPTIONS

The SVE pilot test results indicate that the existing VCBs are not able to produce adequate flow and radius of influence on the main sand unit where free-phase hydrocarbons are present.

The test results also indicate that the VCS could be optimized through the replacement of the existing VCBs in order to provide more vacuum influence, as well as an increase in the removal rate of hydrocarbons. Replacement of the existing VCBs (with new wells located within approximately 5 feet of the existing VCBs) is expected to increase performance of the existing vapor control system. However, the increased efficiency of the wells is expected to have an impact on other components of the system. Those impacts are summarized below:

- The increased efficiency at the new wells is expected to also increase the mass of hydrocarbons that will require treatment through the TTU. The current TTU should be able to handle the additional loading. However, it lacks datalogging and alarm telemetry, is not adequately winterized, is at least 12 years old, and the operational costs (i.e. natural gas) are higher than other available technologies. A cost-benefit analysis between upgrading the existing TTU and providing a new thermal treatment unit will be conducted during design of the VCS upgrade.

- The replacement wells will be installed above the current groundwater elevation in the sand to reduce the potential for water entrainment in the system. However, the wells are still expected to produce humid air from the sand layer where it will be extracting air. The long runs of piping to the blowers and treatment will allow this humid air to condense some of its water. If not removed from the system, this condensed water entrained in the system will become trapped in the detonation flame arrestor elements and could go on to damage the blower and/or TTU.

  The current water removal tanks (buried belowground) are no longer operational and are not able to “knockout” this entrained water. Therefore, a new in-line water/water vapor knock-out pot (with demister pad) will be required between the VCB network and the blower to eliminate this concern. This will allow for automated removal of entrained water and eliminate the potential for impairment of the arrestor elements and damaging the blower and/or TTU.

- As with the TTU, a cost/benefit analysis will be required for the existing vacuum blowers. Currently, one blower is operational with the other not operable. A review of the existing blower(s) performance and reliability compared with the installation of a new system will be evaluated during the design.

Expansion of the VCS system to other affected parts of the Village of Hartford is being evaluated. Insufficient information regarding the extent of the free-phase hydrocarbon (FPH) plume and the subsurface geology currently exists. As data becomes available from the Rapid Optical Screening Tool (ROST) investigation and subsequent verification investigations with monitoring wells, it will be evaluated in regard to potential expansion of the VCS.

5.2 RECOMMENDATIONS

Based on the conclusions of this report, the following recommendations have been developed for upgrading the VCS:

1. Prepare a work plan outlining the activities to be completed as part of the design and implementation of the VCS system upgrade. This will include the recommended design approach for use of existing system components (with upgrades) or new equipment, replacement wells, and conceptual approach for system datalogging and telemetry. A schedule for completion of the design, construction and expected startup of the upgraded system will also be included in this work plan.

2. Develop a design detailing the well replacement methods and locations, equipment upgrades or replacement, and prepare an operations and maintenance manual. In addition, any permit modifications or new permitting necessary will be completed.

3. Implement the replacement of the VCBs, upgrade or replacement of system components and restart the VCS.

4. Evaluate ROST and other data that becomes available in regard to expansion of the VCS either as an interim measure or as part of the final remedy designed for the Village of Hartford.

6.0 VCS UPGRADE WORK PLAN

This work plan has been developed and included in this report based on the recommendation presented in Section 5.0. The Hartford Working Group (HWG) plans to proceed with the upgrade of the existing VCS and evaluate the need for expansion of the system to include other areas of the Village of Hartford not within the expected influence of the upgraded system. The following sections describe the approach to the VCS system upgrade/expansion evaluation, as well as provide an estimated schedule for the planned activities.

6.1 APPROACH

6.1.1 VCS System Upgrade

The system upgrade will begin with development of design drawings and specifications for the system upgrade to be used for contractor solicitation and construction oversight. The upgrade will include the installation and connection of a new extraction well at each VCB location, upgrade of the existing TTU, and installation of a water knockout system.

At the same time the design drawings and specifications are being developed, an evaluation of alternative treatment systems and blower/water removal systems will be conducted. Age of the equipment and not knowing whether the existing TTU can handle the added hydrocarbon load from the new well are factors that will be evaluated in comparison to new system equipment.

Once the design drawings and specifications are complete, new equipment (if deemed appropriate) will be procured. At the same time, contractors for the upgrade construction activities will be solicited and contracted to begin with the installation of the new wells.

The new wells will be constructed first and connected to the current VCB wells in order to facilitate quicker installation. The existing VCB connection to the blowers and treatment system will be utilized for the new wells. Flow from the existing wells will be eliminated by pumping grout into the wells up to the depth of the existing transfer piping. To facilitate safe operation of the VCS during construction, several VCBs will be isolated with blind flanges in the control vaults where the control valves are located. In this way, parts of the system can remain operational during the construction.

At the same time the new extraction wells are installed, at least two new vapor monitoring probes will be installed at the same depth as the extraction well. These probes will be used going forward to monitor the influence of each new well; and therefore, the system effectiveness.

Since it is unknown whether the current TTU can handle the additional hydrocarbon loading, the new wells will have their valves closed and the system will continue to operate through the existing VCBs during construction. Prior to any equipment upgrades, the current TTU can be tested by opening the new wells to determine if additional loading can be handled. The existing VCBs would not be grouted until it can be determined that the existing TTU can handle the additional loading or any new equipment is installed and operational. It is hoped that some additional hydrocarbon extraction from the new wells can be accomplished with the existing TTU, while additional system upgrades and/or new equipment is brought online.

The VCS upgrade will also include the addition of electronic monitoring and telemetry for the system in order to monitor system performance and provide for notification of alarm conditions requiring corrective action. In addition, more operational data will be available to evaluate the system’s long-term performance.

6.1.2 Expansion Evaluation

Data from the SVE pilot test and the free-product hydrocarbon investigation activities will be used to determine if areas with vapors are not within the influence of the current VCS system. In addition, data from the Vapor Migration Pathway Assessment will be considered when evaluating the potential for system expansion. The results of this evaluation will be presented to the Agencies in the form of a technical memorandum along with any recommendations.

6.2 SCHEDULE

A proposed schedule has been developed for the VCS upgrade and expansion evaluation (see Figure 5). The HWG has begun the design activities related to the existing system upgrade following review and approval of the above work plan by the Agencies. Concurrent with the design activities, an evaluation of the existing blowers and thermal treatment unit will be conducted in order to decide if it would be more cost-effective to install new equipment or to just upgrade the existing equipment.

Construction contingency of one month has been added to the system upgrade schedule at this point since the final design has not been completed. It is believed that this is a reasonable schedule assuming that the system equipment would require replacement. In the event that some upgrades are only necessary, it may be possible to tighten the schedule to obtain completion earlier.

Concurrent with the VCS system upgrade activities, the HWG will begin evaluation for the potential to expand the system to include other areas of the Village of Hartford. The evaluation activities will be completed prior to the schedule VCS upgrade. If expansion is deemed appropriate, design activities can begin immediately upon approval of the conceptual approach by the Agencies. At that time, the schedule would be updated to include any system expansion activities.

Clayton
GROUP SERVICES

FIGURES

TABLES

APPENDIX A-1

HSVE-1 WELL LOG AND COMPLETION REPORT

APPENDIX A-2

VCB-1, MP-6S, AND MP-6D WELL LOGS

APPENDIX B

SVE PILOT TEST BLOWER SPECIFICATIONS

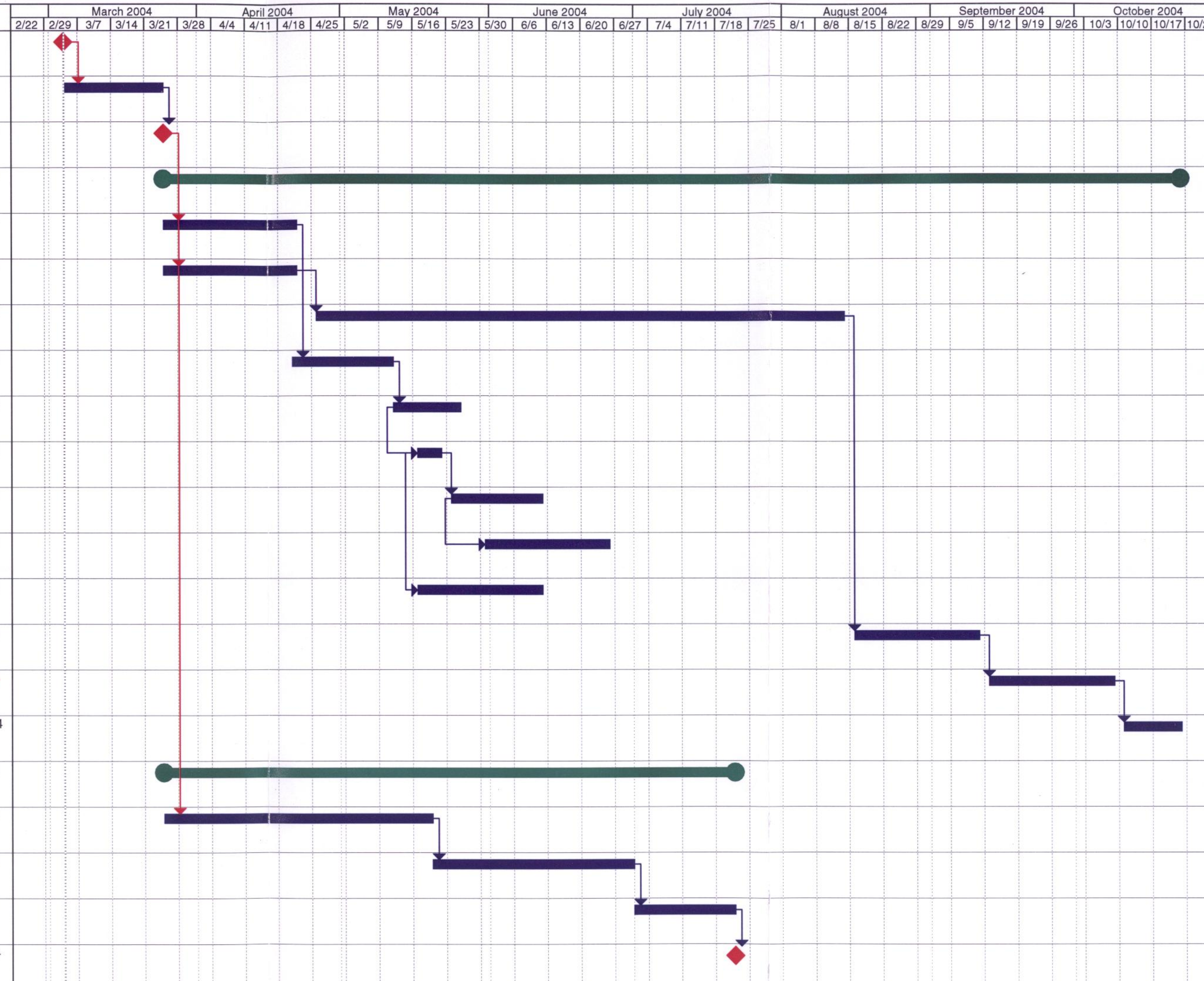
APPENDIX C

AIR SAMPLE ANALYTICAL REPORT

Figure 5
VCS Upgrade Schedule
Hartford, Illinois

Clayton GROUP SERVICES

ID	Task Name	Duration	Start
1	*Submit SVE Pilot Test Report & VCS Upgrade Work Plan to USEPA*	*0 days*	*Thu 3/4/04*
2	Review of Report & Work Plan by USEPA	3 wks	Thu 3/4/04
3	*Approval of VCS Upgrade Work Plan*	*0 days*	*Wed 3/24/04*
4	**VCS System Upgrade**	**152 days**	**Thu 3/25/04**
5	Develop Design Drawing and Specifications	4 wks	Thu 3/25/04
6	Evaluation of Alternative Thermal Treatment and System Component	4 wks	Thu 3/25/04
7	Procure Equipment	16 wks	Mon 4/26/04
8	Solicit Contractors for Construction Quotes	3 wks	Wed 4/21/04
9	Evaluate Quotes/Choose Contractor	2 wks	Wed 5/12/04
10	Clear Utilities/Site Preparation	1 wk	Mon 5/17/04
11	New Well/Vapor Monitoring Probe Installation	3 wks	Mon 5/24/04
12	Excavate Existing VCBs for Connection	4 wks	Mon 5/31/04
13	Upgrade Existing TTU Controls and VCS System Monitoring	4 wks	Mon 5/17/04
14	Install New System Components	4 wks	Mon 8/16/04
15	**Construction Contingency**	**4 wks**	**Mon 9/13/04**
16	System Startup & Shakedown	2 wks	Mon 10/11/04
17	**VCS System Expansion Evaluation**	**85 days**	**Thu 3/25/04**
18	Review of FPH Investigation Data for VCS Expansion Locations	8 wks	Thu 3/25/04
19	Develop Conceptual Design for VCS System Expansion	6 wks	Thu 5/20/04
20	Prepare Technical Memorandum with VCS Conceptual Design	3 wks	Thu 7/1/04
21	Submit Technical Memorandum to USEPA for Review	0 days	Wed 7/21/04



Project: VCS Upgrade Schedule_Rev
Date: Thu 3/4/04

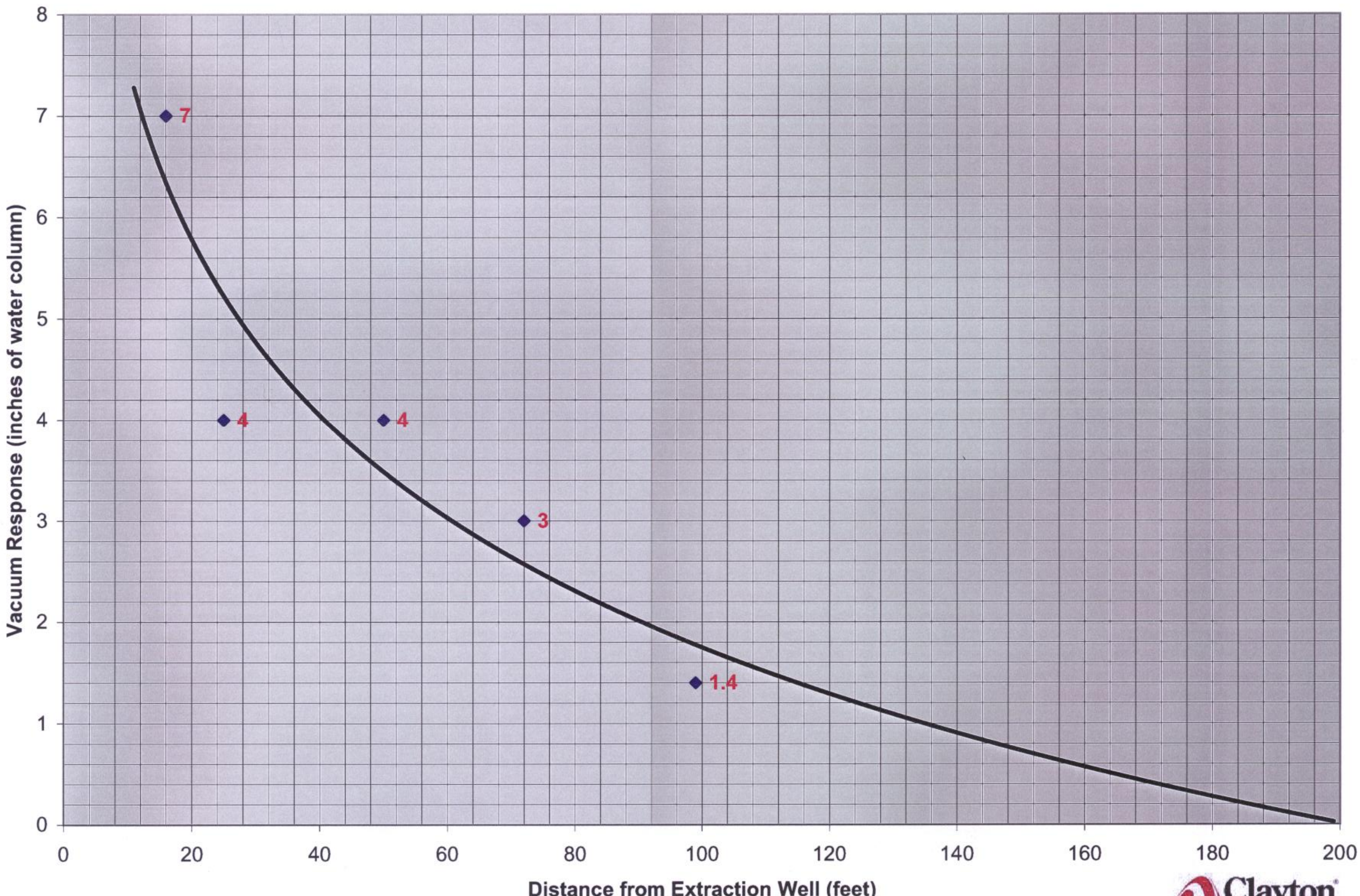
Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

Figure 4

SVE Pilot Test

Flow = 75 scfm

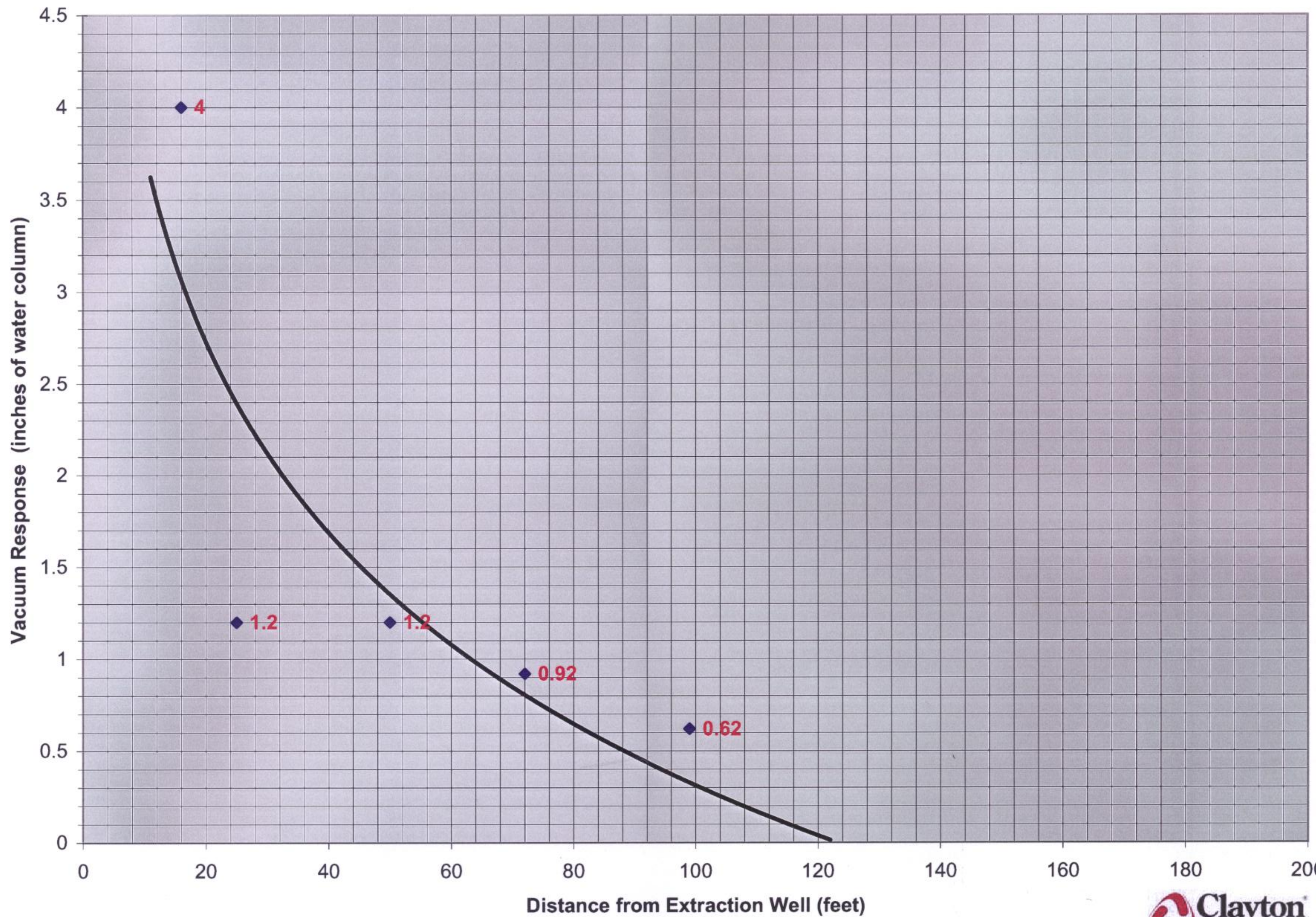
Vacuum = 94 inches of water column



Clayton Group Services

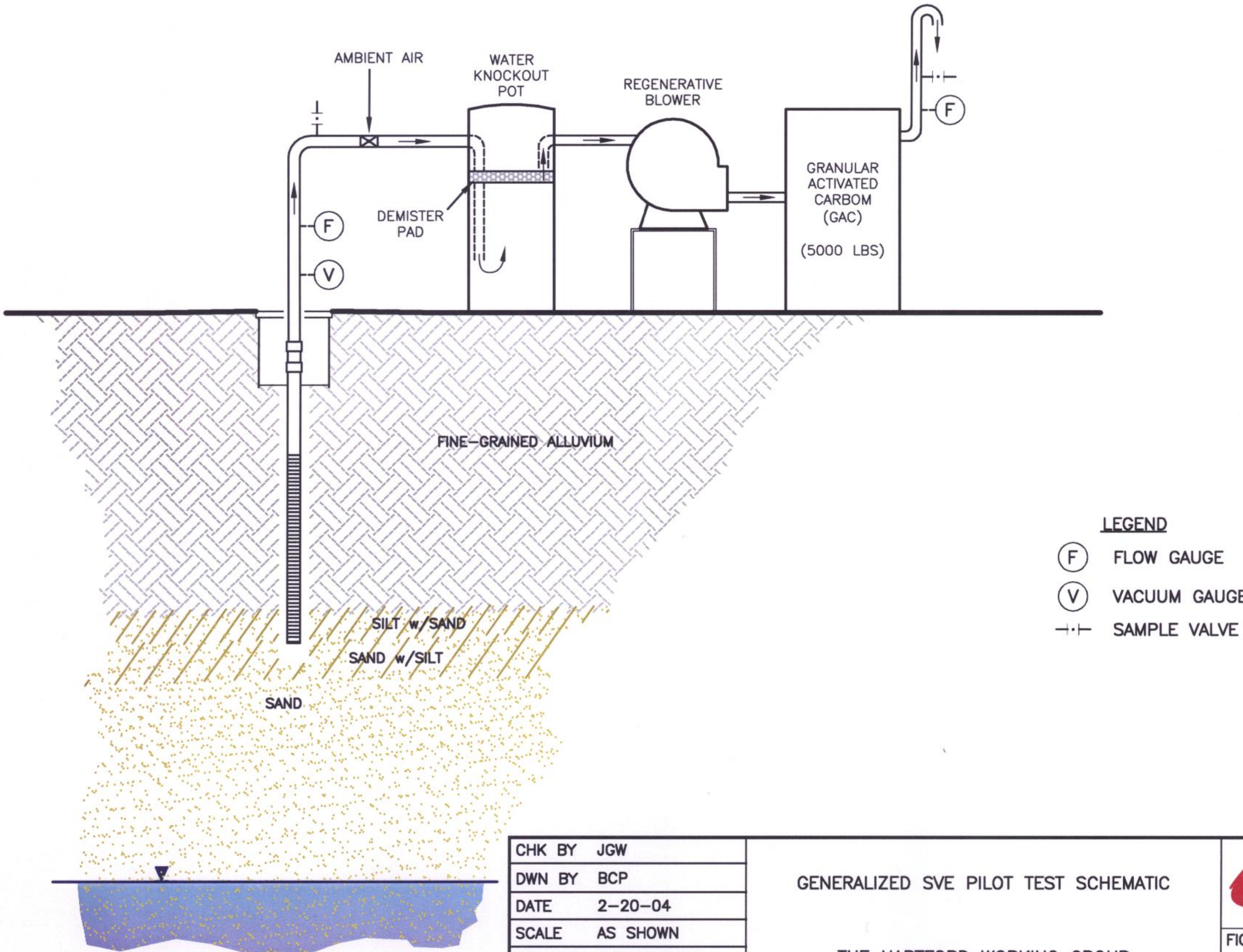
Figure 3

SVE Pilot Test
Flow = 100 scfm
Vacuum = 43 inches of water column



Clayton GROUP SERVICES

GENERALIZED SOIL VAPOR EXTRACTION PILOT TEST SCHEMATIC



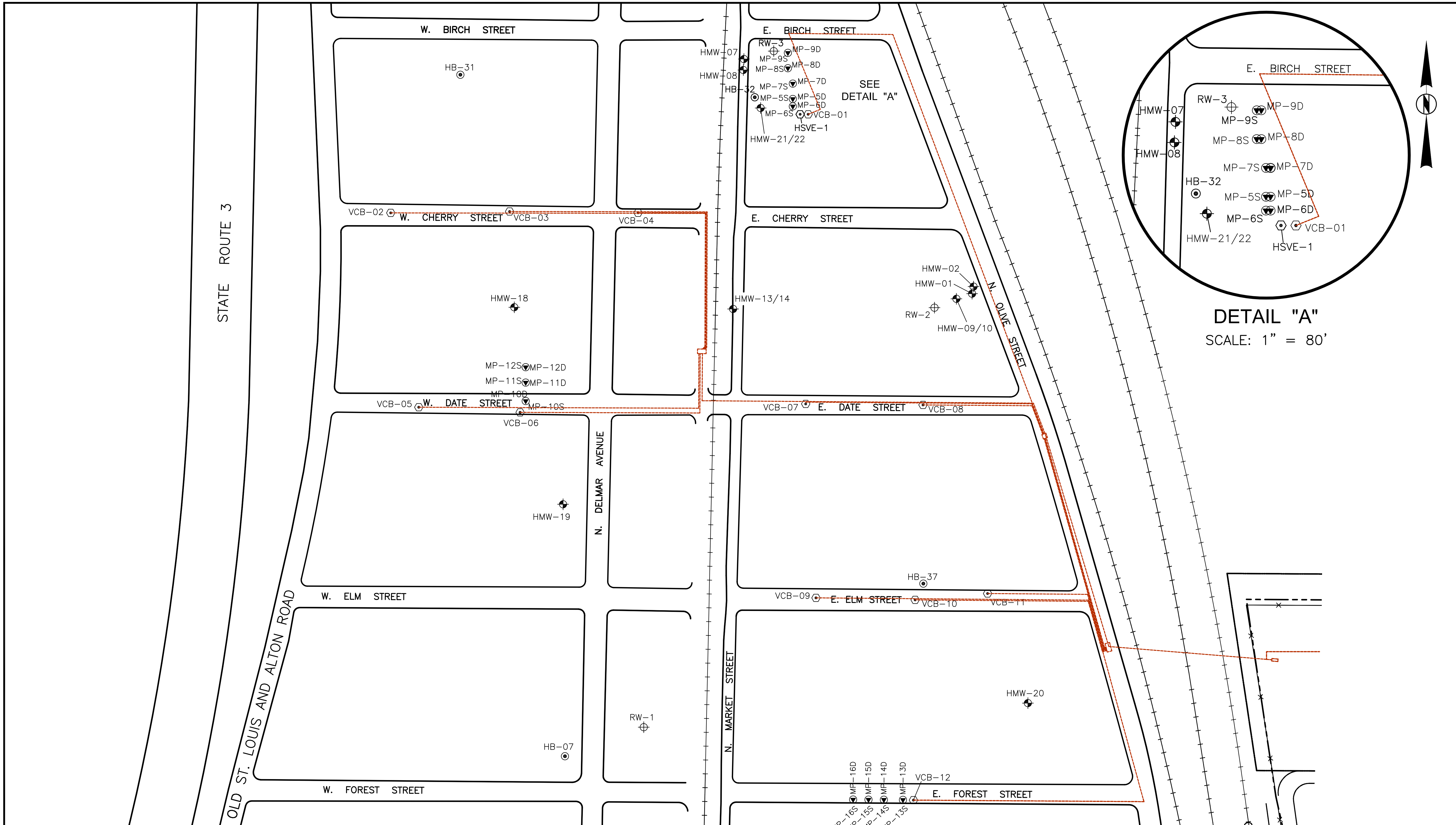
CHK BY	JGW
DWN BY	BCP
DATE	2-20-04
SCALE	AS SHOWN
CAD NO.	0309512001D
PRJ NO.	15-03094.

GENERALIZED SVE PILOT TEST SCHEMATIC

THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

Clayton GROUP SERVICES

FIGURE 2



LEGEND

- SOIL VAPOR MONITORING PROBE (MP)
- MONITORING WELL (HMW)
- MONITORING WELL (HB)
- VAPOR CONTROL BORING (VCB)
- RECOVERY WELL (RW)
- VAPOR CONTROL SYSTEM LINES

NOTE:

SOIL VAPOR MONITORING PROBES (MP) INSTALLED BY CLAYTON ON JULY 23–25, 2003. REMAINING WELLS AND BORINGS INSTALLED BY OTHERS.

SCALE IN FEET

0 75 150 300

CHECK BY	MMN
DRAWN BY	BCP
DATE	2-3-04
SCALE	AS SHOWN
CAD NO.	0309506L
PRJ NO.	15-03095

JANUARY 2004 SVE PILOT TEST LOCATION

THE PREMCOR REFINING GROUP, INC.
HARTFORD, ILLINOIS

Clayton GROUP SERVICES

FIGURE 1

TABLE 3
SVE Pilot Test Radius of Influence Results

The Hartford Working Group / Hartford, Illinois

DATE	TIME	TEST RUNNING TIME	EXTRACTION WELL FLOW RATE (cfm)	EXTRACTION WELL VACUUM (inches of H_2O)	Monitoring Points Radius of Influence Readings (Inches of water)									
					MP-6S	MP-6D	MP-5S	MP-5D	MP-7S	MP-7D	MP-8S	MP-8D	MP-9S	MP-9D
					Distance from HSVE-1									
					16	16	25	25	50	50	72	72	100	100
50 CFM Step Test														
01/14/04	7:30	0:20:00	50	9.5	0.26	0.68	0	0.34	0	0	0	0	0	0
	8:45	1:35:00	50	9	0.24	0.27	0	0.02	0	0	0	0	0	0
75 CFM Step Test														
01/14/04	10:05	0:05:00	75	27	1.05	2.0	0	0.85	0	0.60	0	0.28	0	0.05
	11:05	1:05:00	75	27	1.0	1.70	0	0.72	0	0.3	0	0	0	0
100 CFM Step Test														
01/14/04	11:30	0:10:00	100	43	1.30	1.85	0	0.83	0	0.23	0	0	0	0
	12:35	1:15:00	100	43	1.35	2.10	0	1.10	0	0.50	0	0.20	0	0
	13:25	2:05:00	100	43	1.40	2.50	0	1.15	0	0.70	0	0.40	0	0.15
	14:50	3:30:00	100	43	1.30	4.0	0	1.35	0	1.10	0	0.76	0	0.46
	15:30	4:10:00	100	43	1.35	4.0	0	1.20	0	1.20	0	0.87	0	0.58
	16:50	5:30:00	100	43	1.30	4.0	0	1.20	0	1.20	0	0.92	0	0.62
75 CFM Step Test (High Vacuum)														
01/14/04	18:00	1:00:00	75	94	2.0	7.0	0	4.0	0	3.0	0	1.95	0	1.25
	19:00	2:00:00	75	94	2.0	7.0	0	4.0	0	3.0	0	2.10	0	1.35
	20:00	3:00:00	75	94	2.0	7.0	0	4.0	0	4.0	0	3.0	0	1.40

NOTES: cfm = cubic feet per minute

TABLE 2
SVE Operating Parameters and Analytical Results

The Hartford Working Group / Hartford, Illinois

DATE	TIME	TEST RUNNING TIME	AIR SAMPLE		RESULTS		EXTRACTION WELL FLOW RATE (cfm)	EXTRACTION WELL VACUUM (inches of H_2O)	TOTAL EXHAUST FLOW RATE (Pre-Carbon) (cfm)	TOTAL EXHAUST FLOW RATE (Post-Carbon) (cfm)	SYSTEM VACUUM (inches of H_2O)
			Tedlar Bag	Summa Canister	Tedlar Bag (PPMv)	Summa Canister (PPMv)					
50 CFM Step Test											
01/14/04	7:10	0:00:00	N/C	N/C	N/A	N/A	50	9.5	305	N/T	15
	8:00	0:50:00	E	W	0	2,100	N/T	N/T	N/T	N/T	N/T
	8:30	1:20:00	N/C	N/C	N/A	N/A	50	9	250	N/T	15
	8:40	1:30:00	W	N/C	230	N/A	N/T	N/T	N/T	N/T	N/T
	9:00	1:50:00	N/C	W	N/A	1,600	N/T	N/T	N/T	N/T	N/T
75 CFM Step Test											
01/14/04	10:00	0:00:00	N/C	N/C	N/A	N/A	75	27	230	280	35
	10:10	0:10:00	W	N/C	37	N/A	N/T	N/T	N/T	N/T	N/T
	10:15	0:15:00	N/C	W	N/A	17,000	N/T	N/T	N/T	N/T	N/T
	11:15	1:15:00	N/C	W	N/A	16,000	N/T	N/T	N/T	N/T	N/T
	11:17	1:17:00	E	N/C	0	N/A	N/T	N/T	N/T	N/T	N/T
100 CFM Step Test											
01/14/04	11:25	0:05:00	N/C	N/C	N/A	N/A	100	43	190	240	50
	11:40	0:20:00	N/C	W	N/A	18,000	N/T	N/T	N/T	N/T	N/T
	12:35	1:15:00	N/C	N/C	N/A	N/A	100	43	190	240	50
	12:50	1:30:00	E	N/C	0	N/A	N/T	N/T	N/T	N/T	N/T
	13:25	2:05:00	N/C	N/C	N/A	N/A	100	43	N/T	240	50
	14:50	3:30:00	N/C	N/C	N/A	N/A	100	43	N/T	240	50
	15:30	4:10:00	N/C	N/C	N/A	N/A	100	43	N/T	240	50
	16:50	5:30:00	N/C	N/C	N/A	N/A	100	43	N/T	240	50
	16:55	5:35:00	E	W	0	16,000	N/T	N/T	N/T	N/T	N/T
75 CFM Step Test (High Vacuum)											
01/14/04	17:00	0:00:00	N/C	N/C	N/A	N/A	75	94	N/T	75	N/T
	18:15	1:15:00	N/C	W	N/A	26,000	N/T	N/T	N/T	N/T	N/T
	19:00	2:00:00	N/C	N/C	N/A	N/A	75	94	N/T	75	N/T
	19:45	2:45:00	N/C	W	N/A	22,000	N/T	N/T	N/T	N/T	N/T
	19:50	2:50:00	N/C	E	N/A	24	N/T	N/T	N/T	N/T	N/T
	20:00	3:00:00	N/C	N/C	N/A	N/A	75	94	N/T	75	N/T

NOTES: "W" in sample name indicates influent/well sample.
"E" in sample name indicates exhaust sample.
N/C = Not Collected
N/T = Not Tested
N/A = Not Applicable
cfm = cubic feet per minute
PPMv = parts per million-volume

TABLE 1
VCS Detonation Arrestor Replacement Summary of Vacuum Readings
Influence at VCBs

The Hartford Working Group / Hartford, Illinois

VCB LOCATION	VACUUM MONITORING PROBE	DISTANCE FROM VCB (ft)	VACUUM OLD ARRESTOR (in. WC)	VACUUM NEW ARRESTOR (in. WC)
1	MP6D	13	0.75	0.5
1	MP5D	25	0.0	2.5
1	MP7D	50	0.0	0.0
1	MP8D	75	0.0	0.0
1	MP9D	100	0.0	0.0
6	MP10D	18.5	1.75	1.0
6	MP11D	48.5	0.1	0.25
6	MP12D	73.5	0.0	0.0
12	MP13D	17	2.5	9.0
12	MP14D	48	0.0	1.9
12	MP15D	73	0.15	1.25
12	MP16D	98	0.0	0.21

NOTES: in. WC = inches water column

Clayton GROUP SERVICES

BORING NO: HSVE-1	WELL NO: HSVE-1	PROJECT NO: 15-03095.13-001	PROJECT NAME: Hartford Working Group
BORING LOCATION: 13.0 ft west of VCB-1		COORDINATES: N/A	
DRILLING CO: Phillips Environmental Services		DRILLER: J. Bignall	LOGGED BY: H. Mendygral
DRILLING EQUIP: Hollow Stem Auger		SCREEN INTERVAL: 17.2 ft bgs -7.2 ft bgs	CHECKED BY: M. Mueller
STATIC WATER LEVEL: NA		SCREEN MTL/SLOT: Stainless Steel / 0.020"	START DATE: 1/7/04
BOREHOLE DIA: 6.25"		STICKUP: N/A	START TIME (hours): 9:00
TOP of CASING ELEVATION: NA		G.S. ELEVATION: NA	FINISH DATE: 1/7/04
RISER DIA/MTL/LGTH: 4" / Low Carbon Steel / 5.9'		DEV. METHODS: NA	FINISH TIME (hours): 13:20

DEPTH (ft)	DESCRIPTION	NUMBER	RECOVERY	METHOD	MOISTURE	BLOW CNT (6")	PID SCAN	PID HEADSPACE	REMARKS
0–3	**Fill 0-1.0 ft** Gravel, light gray, moist **Silty Clay 1.0-10.0 ft** Black, moist, some fine to coarse gravel, some roots, softer grades to med. brown at 2.5 ft		3/3	--	M	NA	0	0	Excavated with a rubber tire backhoe for the first three feet
3–5	grades gray at 4.0 ft		2/2	SS	M	NA	0	0	
5–7			2/2	SS	M	NA	0	2.1	
7–7.5	Blind drilled from 7.0-7.5 ft								
7.5–9.5	grades gray with rust mottling at 8.0 ft Stiffer, traces of sand		2/2	SS	M	NA	0	0	
9.5–10	Blind drilled from 9.5-10.0 ft								
10–12	**Clayey Silt 10.0-11.8 ft** Medium brown, very moist, some fine grained sand, softer **Silty Clay 11.8-17.0 ft** Medium brown, gray mottling, very moist, some fine grained sand		1.5/2	SS	M	NA	0	1.9	
12–12.5	Blind drilled from 12.0-12.5 ft								
12.5–14.5			2/2	SS	M	NA	0	1.3	
14.5–15	Blind drilled from 14.5-15 ft								
15–17			1.5/2	SS	M	NA	0	0	
17	End of Boring at 17.0 feet bgs								

Illinois Environmental Protection Agency Well Completion Report

SITE #: 1190505040 COUNTY: Madison WELL #: HSVE-1

SITE NAME: Hartford Free Hydrocarbon Plume / Hartford, Illinois BOREHOLE #: HSVE-1

STATE PLANE COORDINATE: X NA Y NA (or) LATITUDE: NA LONGITUDE: NA

SURVEYED BY: NA ILL REGISTRATION #: NA

DRILLING CONTRACTOR: Philips Environmental Services DRILLER: J. Bignall

CONSULTING FIRM: Clayton Group Services, Inc. GEOLOGIST: H. Mendygral

DRILLING METHOD: Hollow Stem Auger DRILLING FLUIDS (TYPE): None

LOGGED BY: H. Mendygral DATE STARTED: 01/07/04 DATE FINISHED: 01/07/04

REPORT FORM COMPLETED BY: M. Mueller DATE: 1/28/04

ANNULAR SPACE DETAILS

TYPE OF SURFACE SEAL: NA

TYPE OF ANNULAR SEALANT: Concrete

INSTALLATION METHOD: Poured

SETTING TIME: > 24 hours

TYPE OF BENTONITE SEAL-

GRANULAR, PELLET, SLURRY, CHIPS

(CIRCLE ONE)

INSTALLATION METHOD: Poured

SETTING TIME: ~15 minutes

TYPE OF SAND PACK: Industrial Quartz

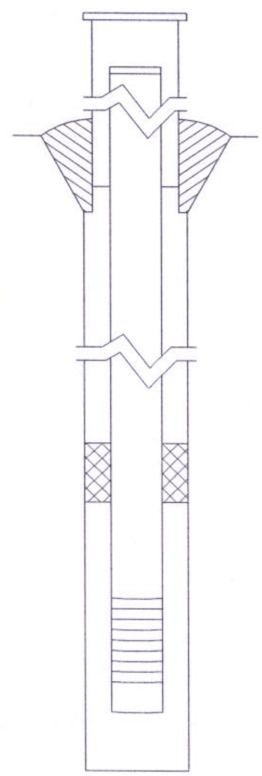
GRAIN SIZE: 01

INSTALLATION METHOD: Poured

TYPE OF BACKFILL MATERIAL: NA

(IF APPLICABLE)

INSTALLATION METHOD: Drilled



ELEVATIONS (MSL) *	DEPTHS (BGS)	(.01 ft)
---	0	TOP OF PROTECTIVE CASING
NA	1.6	TOP OF RISER PIPE
NA	0	GROUND SURFACE
---	---	TOP OF ANNULAR SEALANT
NA	NA	STATIC WATER LEVEL (AFTER COMPLETION)
NA	3	TOP OF SEAL
NA	6	TOP OF SANDPACK
NA	7.17	TOP OF SCREEN
NA	17.17	BOTTOM OF SCREEN
NA	17.17	BOTTOM OF WELL
NA	17.17	BOTTOM OF BOREHOLE

* REFERENCED TO A NATIONAL GEODETIC VERTICAL DATUM

WELL CONSTRUCTION MATERIALS

(CIRCLE ONE)

PROTECTIVE CASING	SS304, SS316, PTFE, PVC OR OTHER:
RISER PIPE ABOVE W.T.	SS304, SS316, PTFE, PVC OR OTHER:
RISER PIPE BELOW W.T.	SS304, SS316, PTFE, PVC OR OTHER:
SCREEN	SS304, SS316, PTFE, PVC OR OTHER:

CASING MEASUREMENTS

DIAMETER OF BOREHOLE (in.)	6.25
ID OF RISER PIPE (in)	4
PROTECTIVE CASING LENGTH (ft)	2'x2'x2'
RISER PIPE LENGTH (ft)	5.67
BOTTOM OF SCREEN TO END CAP (ft)	0.0
SCREEN LENGTH (1st SLOT TO LAST SLOT) (ft)	10
TOTAL LENGTH OF CASING (ft)	15.67
SCREEN SLOT SIZE **	0.02

** HAND-SLOTTED WELL SCREENS ARE UNACCEPTABLE

Checked By: TJG (02/23/04)

RECORD OF SUBSURFACE EXPLORATION

VC BOREHOLE: VCB-1

HARTFORD HYDROCARBON REMEDIATION PROJECT

PHASE I - VAPOR CONTROL SYSTEM

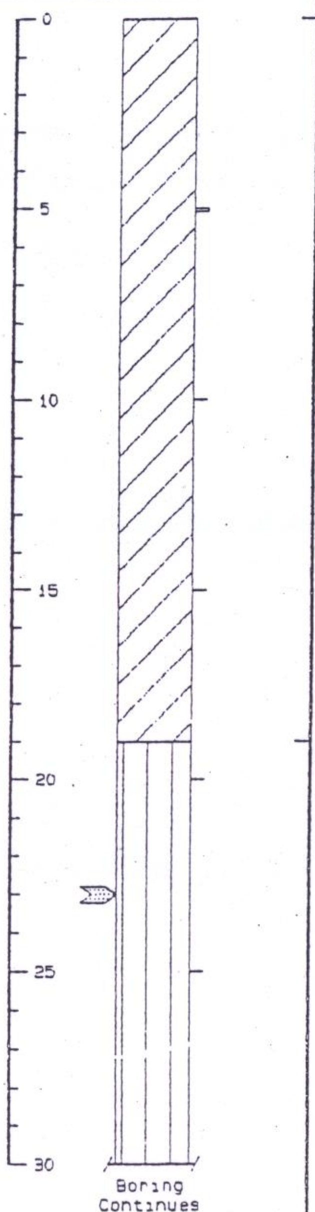
DRILLING METHOD: Hollow Auger DRILLED BY: Crank

DATE DRILLED: 09/06/91 LOGGED BY: Garcia

PROJECT NUMBER: 122489

GROUNDWATER: Encountered at - 23.0 Feet

DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	DESCRIPTION	RECOVERY RATIO in/in	BLOWS PER 6 in.	HNU READINGS ON SAMPLE
		CL	Dark Brown Silty CLAY			
						0/0/0
						0/0/0
						0/0.2/1.0
		ML	Gray Sandy SILT			
						0/0/0.1
						0/1.0/0.4



BEI 024225

RECORD OF SUBSURFACE EXPLORATION

VC BOREHOLE: VCB-1

HARTFORD HYDROCARBON REMEDIATION PROJECT

PHASE I - VAPOR CONTROL SYSTEM

DRILLING METHOD: Hollow Auger DRILLED BY: Crank

DATE DRILLED: 09/06/91 LOGGED BY: Garcia

PROJECT NUMBER: 122489

GROUNDWATER: Encountered at - 23.0 Feet

DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	DESCRIPTION	RECOVERY RATIO in/in	BLOWS PER 6 in.	HNU READINGS ON SAMPLE
30						0/2.0/0.2
		SM	Gray Silty SAND			
35			Total Depth 35.0'			0/70.0/3.0

Remark: 1. Borehole logged from surface to 35.0' by auger cuttings.

BEI 024226

Clayton
GROUP SERVICES

BORING NO: MP-6S	WELL NO: MP-6S	PROJECT NO: 15-03095.06-002	PROJECT NAME: Premcor/Hartford, IL
BORING LOCATION: VCB-1 Vicinity/E. Birch Street		COORDINATES: NA	
DRILLING CO: Roberts Environmental Drilling	DRILLER: J. Crank		LOGGED BY: D. Frieling
DRILLING EQUIP: Geo Cat 642B Geoprobe	SCREEN INTERVAL: 5.0'-10.0'		CHECKED BY: KDC
STATIC WATER LEVEL: NA	SCREEN MTL/SLOT: PVC/0.01"		START DATE: 7/23/03
BOREHOLE DIA: 4"	STICKUP: Flushmount		START TIME (hours): 1240
TOP of CASING ELEVATION: NA	G.S. ELEVATION: NA		FINISH DATE: 7/23/03
RISER DIA/MTL/LGTH: 1.0"/PVC/5.0'	DEV. METHODS: NA		FINISH TIME (hours): 1250

DEPTH (ft)	DESCRIPTION	GRAPHIC	WELL	SAMPLES: NUMBER	RECOVERY	METHOD	MOISTURE	BLOW CNT (6")	PID: SCAN	HEADSPACE	REMARKS
0	FILL 0.0'-0.2' Gravel FILL 0.2'-2.6' Silty clay, moist, dusky, some fine to medium sand, trace roots				2/2	HPU	M	--	--	--	
2	CLAYEY SILT (ML) 2.6'-4.1' Brown, moist, with fine to medium sand				2/2	HPU	M	--	--	--	
4	SILTY CLAY (CL) 4.1'-10.0' Grey, moist, trace fine to medium sand				2/2	HPU	M	--	--	--	
6					2/2	HPU	M	--	--	--	
8	Grades brown with rust mottles and some fine sand at 8.2 feet				2/2	HPU	M	--	--	--	
10	End of Boring at 10.0 feet										

Boring/Well No.: MP-6S

Clayton
GROUP SERVICES

BORING NO: MP-6D	WELL NO: MP-6D	PROJECT NO: 15-03095.06-002	PROJECT NAME: Premcor/Hartford, IL
BORING LOCATION: VCB-1 Vicinity/E. Birch Street		COORDINATES: NA	
DRILLING CO: Roberts Environmental Drilling		DRILLER: J. Crank	LOGGED BY: D. Frieling
DRILLING EQUIP: Geo Cat 642B Geoprobe		SCREEN INTERVAL: 17.35'-27.35'	CHECKED BY: KDC
STATIC WATER LEVEL: NA		SCREEN MTL/SLOT: PVC/0.01"	START DATE: 7/23/03
BOREHOLE DIA: 4"		STICKUP: Flushmount	START TIME (hours): 1035
TOP of CASING ELEVATION: NA		G.S. ELEVATION: NA	FINISH DATE: 7/23/03
RISER DIA/MTL/LGTH: 1.0"/PVC/17.35'		DEV. METHODS: NA	FINISH TIME (hours): 1230

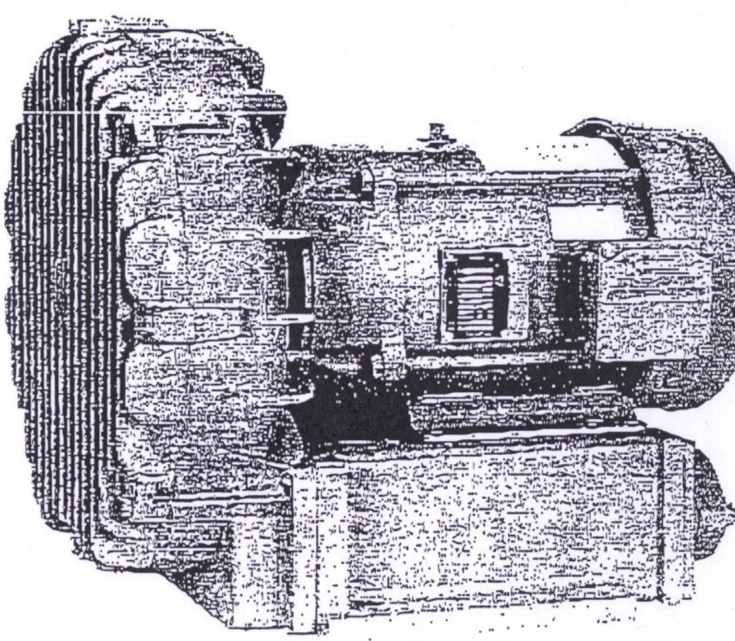
DEPTH (ft)	DESCRIPTION	NUMBER	RECOVERY	METHOD	MOISTURE	BLOW CNT (6")	PID SCAN	PID HEADSPACE	REMARKS
0-2	FILL 0.0'-0.2' Gravel; FILL 0.2'-2.6' Silty clay, moist, dusky, some fine to medium sand, trace roots		2/2	HPU	M	--	0	0	
2-4	CLAYEY SILT (ML) 2.6'-4.1' Brown, moist, with fine to medium sand		2/2	HPU	M	--	0	0	
4-6	SILTY CLAY (CL) 4.1'-16.3' Grey, moist, trace fine to medium sand		2/2	HPU	M	--	0	0	
6-8			2/2	HPU	M	--	0	0	
8-10	Grades brown with rust mottles and some fine sand at 8.2 feet		2/2	HPU	M	--	4.1	9.0	
10-12			2/2	HPU	M	--	9.3	71.7	
12-14			2/2	HPU	M	--	5.7	19.8	
14-16			2/2	HPU	M	--	14.1	42.8	
16-18	CLAYEY SILT (ML) 16.3'-17.4' Brown, moist, trace fine sand; SILTY SAND (SM) 17.4'-23.6'		1/2	HPU	M	--	24.2	86.1	
18-20	Grey, saturated, fine sand, petroleum-like odor		1/2	HPU	S	--	17.8	74.3	

BORING NO: MP-6D	WELL NO: MP-6D	PROJECT NO: 15-03095.06-002	PROJECT NAME: Premcor/Hartford, IL

DEPTH	DESCRIPTION	GRAPHIC	WELL	SAMPLES NUMBER	RECOVERY	METHOD	MOISTURE	BLOW CNT (6")	PID SCAN	HEADSPACE	REMARKS
	Grades black with petroleum-like odor from 20.5 to 23.2 feet				2/2	HPU	S	--	46.5	155	
22					2/2	HPU	S	--	0	0.4	
24	**CLAYEY SILT (ML) 23.6'-24.2'** Brown, saturated, some fine sand, petroleum-like odor										
	SAND (SW) 24.2'-26.7' Black, saturated, fine to medium sand, some silt, petroleum-like odor				2/2	HPU	S	--	122	25.4	
26 / 8	**SILTY SAND (SM) 26.7'-28.0'** Brown, saturated, fine sand, petroleum-like odor				2/2	HPU	S	--	4.3	0	
28	End of Boring at 28.0 feet										
30											
32 / 10											
34											
36											
38											
12 / 40											

EN 808 & CP 808 Three-Phase Sealed Regenerative Blower w/Explosion-Proof Motor

FEATURES
- Manufactured in the USA – ISO 9001 compliant
- Maximum flow: 350 SCFM
- Maximum pressure: 90 IWG
- Maximum vacuum: 97 IWG
- Standard motor: 7.5 HP, explosion-proof
- Cast aluminum blower housing, cover, impeller & manifold; cast iron flanges (threaded); teflon lip seal
- UL & CSA approved motor with permanently sealed ball bearings for explosive gas atmospheres Class I Group D minimum
- Sealed blower assembly
- Quiet operation within OSHA standards

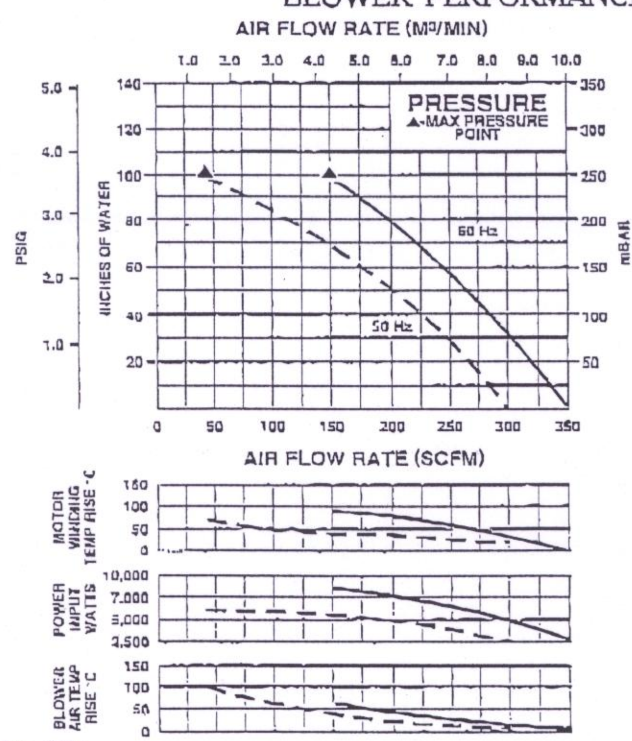


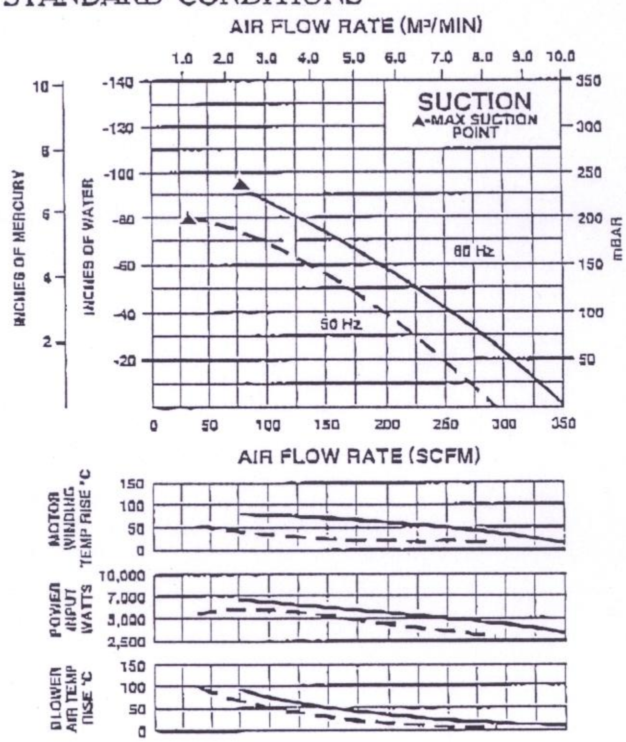
MOTOR OPTIONS
- International voltage & frequency (Hz)
- Chemical duty, high efficiency, inverter duty or industry-specific designs
- Various horsepowers for application-specific needs

BLOWER OPTIONS
- Corrosion resistant surface treatments & sealing options
- Remote drive (motorless) models
- Slip-on or face flanges for application-specific needs

ACCESSORIES (See Catalog Accessory Section)
- Flowmeters reading in SCFM
- Filters & moisture separators
  Pressure gauges, vacuum gauges & relief valves
- Switches – air flow, pressure, vacuum or temperature
- External mufflers for additional silencing
- Air knives (used on blow-off applications)
- Variable frequency drive package

BLOWER PERFORMANCE AT STANDARD CONDITIONS



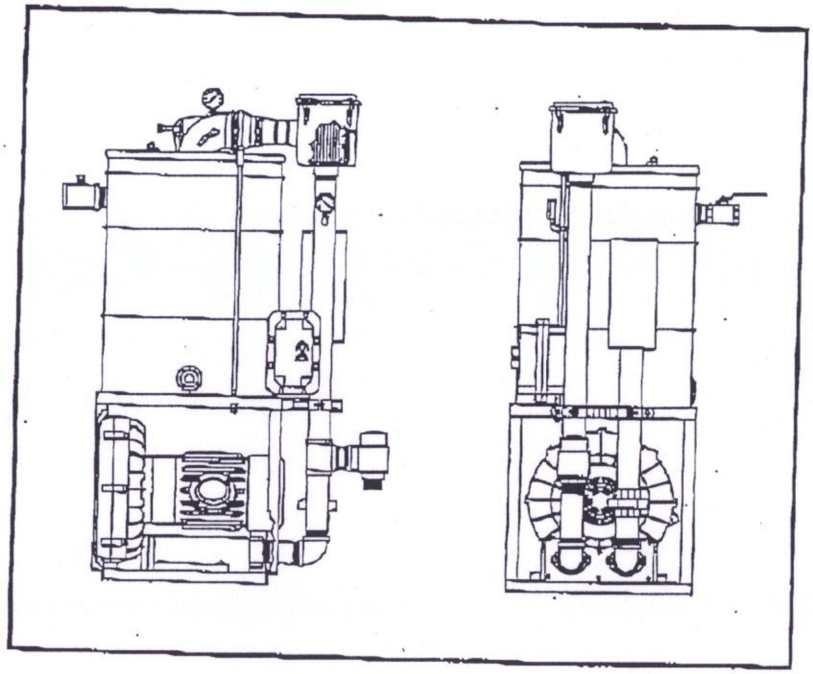


Rev. 2/01

AMETEK Rotron Industrial Products, Saugerties, NY 12477 • e mail: rotronindustrial@ametek.com • internet: www.rotronindustrial.com

SOIL VAPOR EXTRACTION SYSTEMS

Skid-Mounted-CE808/3



Specifications:	
Maximum overall dimensions (LxWxH; inches)	43x28x67
Weight (pounds)	470
Required incoming power	230V, 3ϕ
Maximum total amperage (amps)	27
Recommended minimum generator performance (kVA) [1]	32
Air Inlet	3"
Air discharge	2-1/2" FPT

Performance:	
Air flow (SCFM) @ 6" Hg	120
Air flow (SCFM) @ 4" Hg	200
Air flow (SCFM) @ 2" Hg	280

Typical features [2]:

- NEMA 4 motor starter
- Explosion proof blower motor
- Air flow kit

Notes:

[1] – Generator sizing is estimated. Please contact generator supplier for generator selection.

[2] – Some rentals do not have airflow meters, or XP motors. If these items are required, please notify Carbonair.

PRODUCT DATA SHEET
VFV SERIES FILTERS
MODEL VF-5000

Tetrasolv Filtration

GENERAL DESCRIPTION

The VF-5000 filter is a media filter vessel designed to treat vapor streams where pressure drop is a strong concern. While the typical design application is a activated carbon adsorbtion unit, the filter can easily accommodate many medias. The sturdy construction makes these filter vessels ideal for long term treatment units. Some applications include:

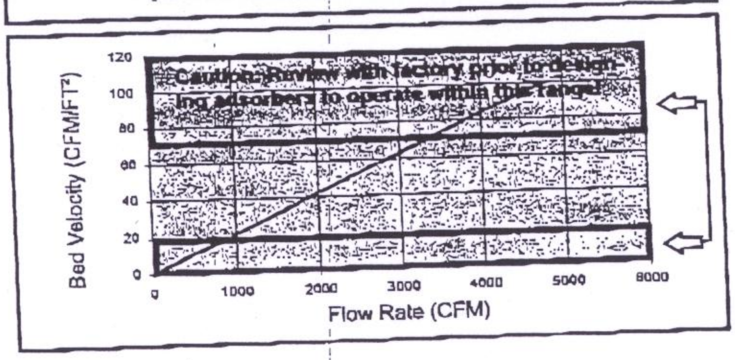
- Soil Vapor Extraction Treatment
- Air Stripper Off Gas Treatment
- Odor Removal System
- Storage Tank Purge Vapor Treatment
- Pilot Study
- Industrial Process Treatment

VF-5000 STANDARD SPECIFICATIONS

Specification	Specification Value	Options
Materials (Vessel)	Carbon Steel	Stainless Steel
Materials (False Floor)	Carbon Steel	Polypropylene, PVC, 304SS, 316SS
Internal Coating	Polyamide Epoxy Resin	Vinyl Ester, PVC
External Coating	Epoxy Mastic (Light Gray)	Any available coating
Maximum Pressure	3 PSIG	Specials Designs Available
Maximum Temperature	350° F	Up to 650° F
Cross Sectional Bed Area	48 FT^2	Special Sizes Available
Bed Depth	3.7 FT (Using 5000 Lbs. 4*10 GAC)	Dependent upon supplied media
Bed Volume	179 FT^3 (Using 5000 Lbs. 4*10 GAC)	NA

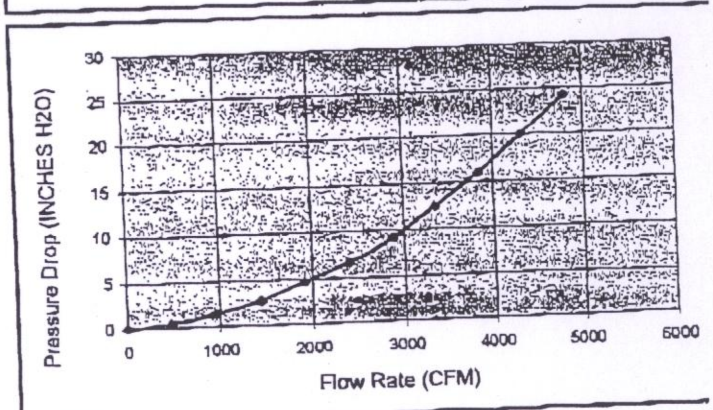
BED VELOCITY GRAPH

(Line Indicates Flow to Velocity Relationship)



PRESSURE DROP GRAPH

(As Filled - 4x10 GAC)



Related Bulletins:
B99-M212A - O&M Manual - VFV-1000 Filter
B99-06A - About Pressure Drop
B99-07A - Usage-Rates

1200 E. 26th Street - Anderson, Indiana 46016
Ph#: 765-643-3941 Fax: 765-643-3949 Email: info@tetrasolv.com

2665 Park Center Drive, Suite D   Simi Valley, California 93065   (805) 526-7161 ph   (805) 526-7270 fax

Columbia Analytical Services INC.
An Employee - Owned Company

LABORATORY REPORT

Client:	CLAYTON GROUP SERVICES	Date of Report:	02/04/04
Address:	3140 Finley Road	Date Received:	01/19/04
	Downers Grove, IL 60515	CAS Project No:	P2400083
Contact:	Mr. Brad Martin	Purchase Order:	15-03095.13-001

Client Project ID: Hartford Work Group/15-03095.13-001

Nine (9) Stainless Steel Summa Canisters labeled:

"SC1F-50A"	"SC1F-50B"	"SC1F-75A"	"SC1F-75B"	"SC1F-100A"
"SC1F-100B"	"SC1F-75-2A"	"SC1F-75-2B"	"SCEF-75-2A"	

The samples were received at the laboratory under chain of custody on January 19, 2004. The samples were received intact. Please refer to the sample acceptance check form for additional information. The results reported herein are applicable only to the condition of the samples at the time that they were received at the laboratory.

Total Petroleum Hydrocarbons as Gasoline Analysis

The samples were analyzed for total petroleum hydrocarbons as gasoline per modified EPA Method TO-3 using a gas chromatograph equipped with a flame ionization detector (FID).

The results of analyses are given on the attached data sheet. All results are intended to be considered in their entirety, and Columbia Analytical Services, Inc. (CAS) is not responsible for utilization of less than the complete report.

Reviewed and Approved:

Regan Lau
Analytical Chemist
Air Quality Laboratory

Reviewed and Approved:

Wade Henton
GC-VOA Team Leader
Air Quality Laboratory

COLUMBIA ANALYTICAL SERVICES, INC.

RESULTS OF ANALYSIS

Client: **Clayton Group Services**
Client Project ID: **Hartford Work Group/15-03095.13-001**

CAS Project ID: P2400083

Total Petroleum Hydrocarbon (TPH)

Test Code: Modified EPA TO-3
Instrument ID: HP5890 II/GC11/FID
Analyst: Regan Lau
Sampling Media: Summa Canister(s)
Test Notes:

Date Collected: 1/14/04
Date Received: 1/19/04
Date Analyzed: 1/20/04
Volume(s) Analyzed: 1.00 ml
0.10 ml

Client Sample ID	CAS Sample ID	D. F.	Total Petroleum Hydrocarbons as Gasoline Result mg/m³	MRL mg/m³	Result ppmV	MRL ppmV	Data Qualifier
SC1F-50A	P2400083-001	1.20	**7,500**	22	**2,100**	6.1	
SC1F-50B	P2400083-002	1.25	**5,700**	23	**1,600**	6.4	
SC1F-75A	P2400083-003	1.36	**60,000**	240	**17,000**	69	
SC1F-75B	P2400083-004	1.36	**56,000**	240	**16,000**	69	
SC1F-100A	P2400083-005	1.37	**62,000**	250	**18,000**	70	
SC1F-100B	P2400083-006	1.42	**56,000**	260	**16,000**	73	
SC1F-75-2A	P2400083-007	1.58	**92,000**	280	**26,000**	81	
SC1F-75-2B	P2400083-008	1.63	**78,000**	290	**22,000**	83	
SCEF-75-2A	P2400083-009	1.24	**83**	22	**24**	6.3	
Method Blank	P040120-MB	1.00	ND	18	ND	5.1	

Parts Per Million Results Are Based on a Molecular Weight of 86.18
ND = Compound was analyzed for, but not detected above the **laboratory reporting limit**.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

Verified By: KMH Date: 02/02/04

Columbia Analytical Services, Inc.
Sample Acceptance Check Form

Client: Clayton Group Services　　Work order: P2400083

Project: Hartford Work Group/15-03095.13-001

Sample(s) received on: 1/19/04　　Date opened: 1/19/04　　by: SM

Note: This form is used for <u>all</u> samples received by CAS. The use of this form for custody seals is strictly meant to indicate presence/absence and not as an indication of compliance or nonconformity. Thermal preservation and pH will only be evaluated either at the request of the client or as required by the method/SOP.

#	Question	Yes	No	N/A
1	Were **custody seals** on outside of cooler/Box?	☐	☒	☐
	Location of seal(s)? ______ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
	Were custody seals on outside of sample container?	☐	☒	☐
	Location of seal(s)? ______ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
2	Were **sample containers** properly marked with client sample ID?	☒	☐	☐
3	Did **sample containers** arrive in good condition?	☒	☐	☐
4	Were **chain-of-custody** papers used and filled out?	☒	☐	☐
5	Did **sample container labels** and/or tags agree with custody papers?	☒	☐	☐
6	Was **sample volume** received adequate for analysis?	☒	☐	☐
7	Are samples within specified holding times?	☒	☐	☐
8	Was proper **temperature** (thermal preservation) of cooler at receipt adhered to?	☐	☐	☒
	Cooler Temperature NA °C			
	Blank Temperature NA °C			
9	Is pH (acid) **preservation** necessary, according to method/SOP or Client specified information?	☐	☒	☐
	Is there a client indication that the submitted samples are **pH** (acid) preserved?	☐	☐	☒
	Were **<u>VOA vials</u>** checked for presence/absence of air bubbles?	☐	☐	☒
	Does the client/method/SOP require that the analyst check the sample pH and <u>if necessary</u> alter it?	☐	☐	☒
10	**Tubes:** Are the tubes capped and intact?	☐	☐	☒
	Do they contain moisture?	☐	☐	☒
11	**Badges:** Are the badges properly capped and intact?	☐	☐	☒
	Are dual bed badges separated and individually capped and intact?	☐	☐	☒

Lab Sample ID	Required pH	pH (as received, if required)	VOA Headspace (Presence/Absence)	Receipt / Preservation Comments
P2400083-001			NA	
P2400083-002			NA	
P2400083-003			NA	
P2400083-004			NA	
P2400083-005			NA	
P2400083-006			NA	
P2400083-007			NA	
P2400083-008			NA	
P2400083-009			NA	
P2400083-010			NA	

Explain any discrepancies: (include lab sample ID numbers):

Columbia Analytical Services INC.
An Employee - Owned Company

Air Quality Laboratory
2665 Park Center Drive, Suite D
Simi Valley, California 93065
Phone (805) 526-7161
Fax (805) 526-7270

Chain of Custody Record
Analytical Service Request

Client/Address: Clayton Group Services, Inc.
3140 Finley Road
Downers Grove, IL 60515

Phone: 630-795-3249 Fax: 630-795-1130

Email: bmartin@claytongrp.com

Contact: Brad Martin

Sampler (Signature): Brad Martin

Project Name: Hartford Work Group

Project Number: 15-03095.13-001

Sampling Location: Hartford, IL

P.O. #/Billing Information: 15-03095.13-001

CAS Project No.: P2400083

Analysis: TPH as Gasoline EPA Method TO-3

Expected Turnaround Time: 24 Hr 48Hr 3Day 4Day 5Day Standard (10 Business Days)

Cooler / Blank Temp____

Client Sample ID	Date Collected	Time Collected	Lab Sample No.	Type of Sample	Container ID (Serial #)	Flow Controller (Serial #)	Sample Volume (Liters)	TPH as Gasoline EPA Method TO-3				Expected Turnaround Time	Comments (e.g., preservative or specific instructions)
SCIF-50A	1/14/04	0800	-1		00181			✓					SC0036
SCIF-50B	1/14/04	0900	-2		00064			✓					13
SCIF-75A	1/14/04	1015	-3		00339			✓					125
SCIF-75B	1/14/04	1115	-4		00566			✓					26
SCIF-100A	1/14/04	1140	-5		00377			✓					524
SCIF-100B	1/14/04	1655	-6		00555			✓					306
SCIF-75-2A	1/14/04	1815	-7		SC00470			✓					470
SCIF-75-2B	1/14/04	1943	-8		00483			✓					414
SCEF-75-2A	1/14/04	1950	-9		00298			✓					142
					SC005607								

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:	Additional Comments
Brad Martin	1/16/04	11:00am	Sharon Malone	1/19/04	1040	
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:	
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:	

White Copy: Accompanies Samples Yellow Copy: Retained by Client COC #13 7/

Clayton® GROUP SERVICES
3140 Finley Road, Downers Grove, IL 60515
(630) 795-3200 Fax (630) 795-1130

SHEET NO. ______ OF ______
PROJECT 15-03095
DATE 2-10-04
BY JW CKD ______

Hartford Working Group
TPH (as Gasoline) Extraction Calculations

TPH removal rate =

$R_r = C_v \times Q_s$ where

C_v = Hydrocarbon concentration in mg/L
Q_s = flow rate in ft³/min

C_v (at 50cfm) = 5.7 mg/L
R_r (at 50cfm) = 5.7 mg/L × Q_s

= 5.7 mg/L × $\frac{50 ft^3}{min}$

$$= \frac{5.7\ \cancel{mg}}{\cancel{L}} \times \frac{50\ \cancel{ft^3}}{\cancel{min}} \times \frac{1440\ \cancel{min}}{day} \times \frac{28.32\ \cancel{L}}{\cancel{ft^3}} \times \frac{1\ \cancel{kg}}{1{,}000{,}000\ \cancel{mg}} \times \frac{2.205\ lbs}{\cancel{kg}}$$

≈ 26 lb/day

≈ 1.1 lbs/hr

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3140 Finley Road, Downers Grove, IL 60515
(630) 795-3200 Fax (630) 795-1130

SHEET NO. ______ OF ______
PROJECT 15-03095
DATE 2-10-04
BY JW CKD ______

Hartford Working Group

TPH (as gasoline) Extraction Calculations

TPH Removal Rate

$R_r = C_v \times Q_s$ where

C_v = Hydrocarbon Concentration in mg/L

Q_s = Flow Rate in ft³/min

C_v (at 75cfm) = 56 mg/L

R_r (at 75cfm) = 56 mg/L × Q_s

= 56 mg/L × 75 ft³/min

$$= \frac{56\ \cancel{mg}}{\cancel{L}} \times \frac{75\ \cancel{ft^3}}{\cancel{min}} \times \frac{1440\ \cancel{min}}{day} \times \frac{28.32\ \cancel{L}}{\cancel{ft^3}} \times \frac{1\ \cancel{kg}}{1{,}000{,}000\ \cancel{mg}} \times \frac{2.205\ lbs}{\cancel{kg}}$$

= 378 lbs/day

≈ 16 lbs/hr

Clayton® GROUP SERVICES
3140 Finley Road, Downers Grove, IL 60515
(630) 795-3200 Fax (630) 795-1130

SHEET NO. ______ OF ______
PROJECT 15-03095
DATE 2-10-04
BY JW CKD ______

Hartford Working Group
TPH (as gasoline) Extraction Calculations

TPH Removal Rate

$R_r = C_v \times Q_s$ where

C_v = Hydrocarbon concentration in mg/L

Q_s = Flow rate in ft^3/min

C_v (at 100 cfm) $= 56\ mg/L \times Q_s$

$= 56\ mg/L \times 100\ ft^3/min$

$$= \frac{56\ \cancel{mg}}{\cancel{L}} \times \frac{100\ \cancel{ft^3}}{\cancel{min}} \times \frac{1440\ \cancel{min}}{day} \times \frac{28.32\ \cancel{L}}{\cancel{ft^3}} \times \frac{1\ \cancel{kg}}{1{,}000{,}000\ \cancel{mg}} \times \frac{2.205\ lbs}{\cancel{kg}}$$

$= 503$ lbs/day

≈ 21 lbs/hr

Clayton® GROUP SERVICES

3140 Finley Road, Downers Grove, IL 60515
(630) 795-3200 Fax (630) 795-1130

SHEET NO. ______ OF ______
PROJECT 15-03095
DATE 2-10-04
BY JW CKD ______

Hartford Working Group
TPH (as gasoline) Extraction Calculations

TPH Removal Rate

$R_r = C_v \times Q_s$ where

C_v = Hydrocarbon concentration in mg/L

Q_s = Flow rate in ft³/min

$C_v(75\,cfm) = 78\,mg/L \times 75\,ft^3/min$

$$= \frac{78\,\cancel{mg}}{\cancel{L}} \times \frac{75\,\cancel{ft^3}}{\cancel{min}} \times \frac{1440\,\cancel{min}}{day} \times \frac{28.32\,\cancel{L}}{\cancel{ft^3}} \times \frac{1\,\cancel{kg}}{1{,}000{,}000\,\cancel{mg}} \times \frac{2.205\,lbs}{\cancel{kg}}$$

$= 526$ lbs/day

$= 22$ lbs/hr